Predicting Traffic Load in Public Transportation Networks
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Context of the Research

Some Basic Facts:
- PhD study entitled “Supervision in Multimodal Transportation Systems”
- MExCo team, INRIA and LSV, CNRS & ENS de Cachan
- Corporation with IRT SystemX: project MIC
- From September 2013 until end of 2016

Major Contribution & Task:
- Stochastic hybrid automaton (SHA) model that can be used to forecast the passenger loads of a multimodal transportation network (TN)
- Supervision strategies for some use cases

Overview of SHA Model

- Every mode captures a particular state in TN’s vehicle operation (which vehicle is stopped at which station, etc.)
- A set of decoupled (for every station one) Itô-stochastic balance equations defines the passenger flow dynamics in a particular mode
- Diffusion terms in balance equations capture uncertainty that comes along with every passenger arrival process associated with the passengers of a particular trip profile
- Deterministic-timed (arrival of a vehicle at a station upon its departure) and probabilistic passenger load-driven transitions (departure of a vehicle from a station) among a finite set of modes

Infrastructure of TN in SHA

- Stations, transportation grids, and an interface between both (defining all passenger transfer possibilities) capture the infrastructure of TN
- The paths of all vehicle missions are unfolded in the SHA’s infrastructure graph for the easy specification of the passengers’ mission-aware trip profiles
- Passenger transfers spread perturbations across the different modes and lines

Routing of Passenger Flows in Balance Equations

- Balance equations relate passenger load vectors via locally-defined (re-)routing matrices
- Every element of a passenger load vector gives the number of passengers w.r.t. a particular trip profile at a discrete point in a station or on-board a vehicle docked to that station
- Every passenger flow is a vector with a passenger load-dependent magnitude and is thus demand- and capacity-sensitive

Forecasting Passenger Loads & Future Work

Problem:
- Probabilistic passenger load-driven mode transitions can occur at any time within uncountable time intervals

Workaround:
- Pinpoint all mode transition times to an equidistantly-spaced mesh → discretized mode graph that has to be computed time-layer by-layer (iterative propagation of prob. densities)

Future Work & Outlook

Efficient Implementation of Forecasting Algorithm:
- Compute compact discretized mode graph, which disregards everything that does not affect the forecast → fewer numerical integrations
- Decouple all passenger flows in balance equations for the numerical integration of the corresponding Fokker-Planck equations

Apply SHA Model to Different Forecasts:
- Forecast travel times
- Iterative search for bottlenecks without specification of particular target sets

Sample Question:
- Will the passenger load of the platform p in the station s exceed 200 passengers with a probability greater than 0.7 within the next 20 minutes?

Constraints:
- Obtain forecast in time given reasonable computation constraints based on ...
- Exact knowledge of the vehicles’ operational states
- Estimations for all passenger loads

References & Related Links

Deterministic Hybrid Automaton Model:

Stochastic Hybrid Automaton Model:

Research Abstract: